INFLUENCE OF BORON ON FLOWER-BUD DEVELOPMENT IN COTTON[1]

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INTRODUCTION

Although the role of boron in plant nutrition has received a great deal of attention in the past few years most investigators have emphasized the relation of this element to the vegetative growth of plants or to imperfections in the fruit. Brenchley and Warington,[2] Johnston and Fisher,[3] Shive,[4] Eaton,[5] and others have called attention to the influence of boron on fruiting but have offered no evidence to show that any particular phase of the fruiting cycle was specifically concerned.

The results reported in this paper emphasize the phase of the reproductive cycle of cotton in which the boron supply may be a limiting factor.

MATERIALS AND METHODS

Jars and special covers of pyrex glass used in other water-culture studies [6] were employed in these experiments. Investigators in this field have generally avoided borosilicate glass, but experience has shown that pyrex glass does not supply sufficient boron to the young cotton seedlings in midsummer to protect them from severe boron deficiency even in the first week of growth (fig. 1).

Salts for the nutrient solutions were of the same lot used in other trace-element studies and for the 1937 cultures chemically pure salts were recrystallized three times from water redistilled from pyrex stills. For the 1938 cultures two additional recrystallizations were made from water double-distilled from pyrex stills.

The basal solution had the following composition:

	Mole
$Ca(NO_3)_2$	0.0030
$MgSO_4$	.0020
KH_2PO_4	.0010

To all cultures was added 0.1 p. p. m. Mn as $MnSO_4.2H_2O$. Iron as ferric tartrate was added as needed. Manganese and boron were the only so-called trace elements added to the culture solutions in 1937 or at the beginning of the 1938 work. However, the 1937 plant leaves never had a satisfactory green color and after the same faint and persistent chlorosis developed in the 1938 cultures, copper as

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[2] BRENCHLEY, WINIFRED E., and WARINGTON, KATHERINE. THE ROLE OF BORON IN THE GROWTH OF PLANTS. Ann. Bot. [London] 41: 167-187, illus. 1927.

[3] JOHNSTON, EARL S., and FISHER, PAUL L. THE ESSENTIAL NATURE OF BORON TO THE GROWTH AND FRUITING OF THE TOMATO. Plant Physiol. 5: 387-392, illus. 1930.

[4] SHIVE, JOHN W. THE ADEQUACY OF THE BORON AND MANGANESE CONTENT OF NATURAL NITRATE OF SODA TO SUPPORT PLANT GROWTH IN SAND CULTURE. N. J. Agr. Expt. Sta. Bul. 603, 36 pp., illus. 1936.

[5] EATON, FRANK M. BORON REQUIREMENTS OF COTTON. Soil Sci. 34: 301-305. 1932.

[6] GEORGIA EXPERIMENT STATION. MANGANESE REQUIREMENTS OF COTTON. Ga. Expt. Sta. Ann. Rpt. (1937-38) 50: 62-63. 1938.

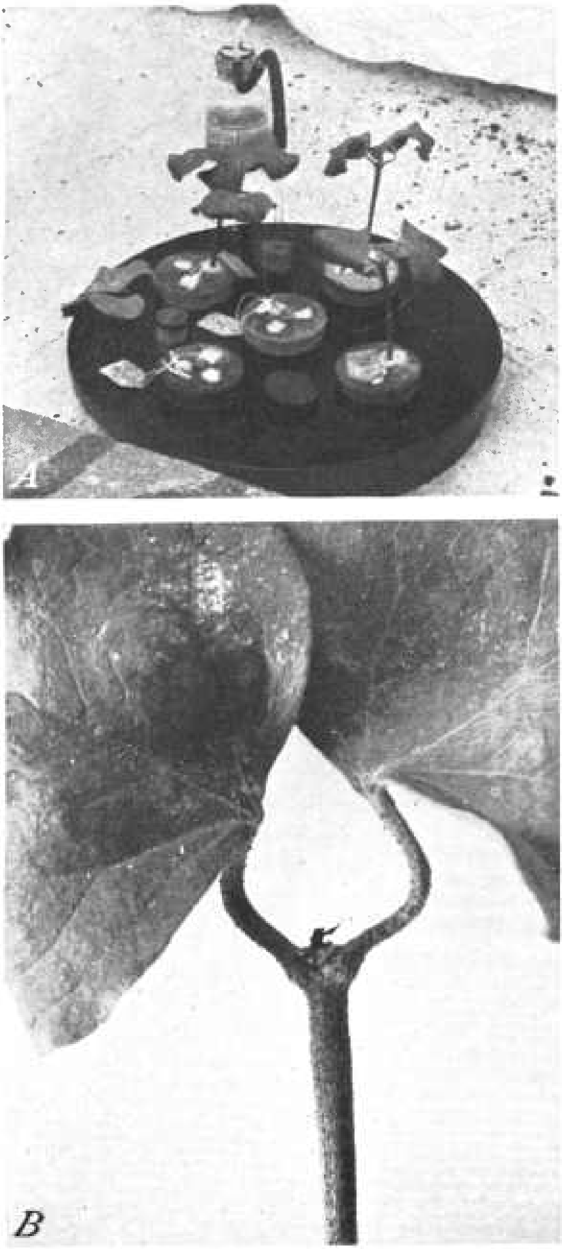

FIGURE 1.—*A*, Cotton seedlings after growing 37 days in a nutrient solution, without added boron, in a pyrex jar; *B*, plant from group in *A* showing failure of terminal bud development.

$CuSO_4.5H_2O$ and zinc as $ZnCl_2$ at the rate of 0.01 p. p. m. and 0.1 p. p. m., respectively, were added to each jar on July 20 and at each renewal thereafter. The color of the leaves of these plants after these additions was satisfactory. Boron was added as boric acid. The stock solutions and distilled water used in preparing these nutrients were stored and handled in pyrex glass.

The solutions were renewed June 29, July 16, August 5, 19, 27, 1937, and June 15, 27, July 14, 25, and August 8, 19, 1938. In the later stages of growth, the nitrogen was almost completely absorbed within 3 or 4 days after the solutions were renewed, and consequently growth was limited by insufficient nutrient supply.

The delinted seed of the Durango variety which was used in these cultures contained 23 p. p. m. of boron or about 3 gamma per seed. Fifteen seedlings were started in each jar and they were thinned to five after about 2 weeks and to two after about 5 weeks. After the beginning of the fruiting stage in 1937, the flower buds, or squares, were tagged with white tags and counted once each week. However, in the late-growth stages it was found that many buds were formed and shed within 1 week and that no accurate record of total buds formed could be obtained for the 1937 crop. In the 1938 studies the buds were tagged and counted twice each week. Every morning white tags were removed from newly opened blooms and replaced by colored tags. In the 1938 cultures the colored tags were dated.

EXPERIMENTAL DATA

In the 1937 cultures there was no noticeable difference in the general appearance of the plants at the different boron levels for the first 8 or 9 weeks. Abscission of flower buds and scarcity of blooms, however, were noticeable within the first 9 weeks on plants at the 0.1-p. p. m. boron level. As the growing period advanced, the young buds were shed when they were much smaller and, finally, there was some irregularity in leaf development in the growing tops of these plants, indicating a deficiency of boron for the young growing points. At this stage the young flower buds blackened and died in a manner comparable to that seen in terminal buds in cases of severe boron deficiency.

TABLE 1.—*Influence of boron supply upon growth and flowering of cotton planted June 15 and harvested Sept. 11, 1937*

[Average of four plants]

Boron added (p. p. m.)	Height of plants	Green weight of plants	Flower buds Sept. 11	Blooms
	Centimeters	*Grams*	*Number*	*Number*
0.1	163.7	1,076.0	53.1	10.7
1.0	172.5	1,257.0	46.7	53.2
5.0	148.7	1,199.0	29.7	45

As the data of table 1 show, there was no decided difference in the vegetative growth of the plants at the different boron levels, but the 0.1-p. p. m. boron plants produced very few blooms. Most of the green-weight difference was due to the young bolls on the plants at the higher boron levels.

The experiment was repeated on a larger scale in 1938. Again there was little difference in the appearance of the plants at the two boron levels for the first 8 weeks. The flower buds on the plants at the lower boron level developed to a fair size and then most of them became chlorotic, the bracts flared open, and they dropped. As the growing period advanced, the flower buds abscissed at smaller sizes so that during the last 10 days of the study they darkened and dropped when they were so small that they were scarcely recognizable, and it is probable that the recorded figure for total flower buds for this series is low in spite of the fact that they were tagged twice each week. About August 15 the branches near the tops of this group of plants became very brittle, developed short internodes, and the leaf buds tended to darken and show other irregularities in development usually associated with boron deficiency. This development is illustrated in figure 2. As table 2 shows, the results are in general agreement with those of 1937.

In this case the mean difference in flowers per plant, 40.4, with a pooled standard deviation of 10, is highly significant.

FIGURE 2.—Low-boron plant (0.1-p. p. m. group, Table 2), August 28, 1938, showing irregularity of leaf development near top.

TABLE 2.—*Influence of boron supply upon growth and flowering of cotton planted June 3 and harvested Aug. 28, 1938*

[Average of 14 plants]

Boron added (p. p. m.)	Height of plants	Green weight of plants	Flower buds Aug. 28	Flower buds shed	Total flower buds	Blooms
	Centimeters	*Grams*	*Number*	*Number*	*Number*	*Number*
0.1	155.1	1,149.0	54.6	98	162.9	10.2
1.0	182.0	1,303.0	62.1	40	153.2	50.6

DISCUSSION

Since the nutrient concentration was not held constant, these results give little indication of the optimum concentration of boron for growth and fruiting of cotton in water culture. They do emphasize, however, the importance of boron in the flowering of cotton and indicate that an insufficiency of this element may be the cause of unfruitfulness. Although approximately 70 percent of the flowers of the low-boron plants, 1938 series, appeared by August 10, before boron deficiency had become manifest in the vegetative parts of the plants, the abscission of young buds from this group of plants and from those at the same level the previous year was apparently abnormal in the early stages. This observation along with the fact that vegetative growth was not severely checked at any stage in the low-boron series suggests that the concentration of this element necessary for flower-bud development in cotton is higher than that required by the vegetative parts. But the blackening of young flower buds in a manner quite similar to that observed in young leaf buds in cases of severe boron deficiency also suggests that the specific effects of the deficiency upon the tissues involved are probably the same.

From the records of total flower buds per plant (table 2) it may be seen that the boron level which was too low for flower-bud development had no apparent effect on flower-bud initiation.

SUMMARY

Water-culture studies of the boron requirements of cotton brought out the fact that this element is necessary for flower-bud development in this plant, and that flowering may be seriously limited by a supply of boron that is sufficient for fair vegetative growth.

There is no evidence from these results that boron has any relation to flower-bud initiation in cotton.